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Abstract

ADVANCES IN AQUEOUS PROCESSING OF POWER REACTOR FUELS

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Processes for the recovery of fissionable and fertile materials from irradiated fuels by aqueous dissolution and organic solvent extraction and/or ion exchange have been extended for application to most types of power reactor fuels by the development of new fuel dissolution processes. Most research and development effort has been focused on the feed preparation steps, and the effect of fuel irradiation level on the solvent systems. New processes have been developed for the recovery of most radioactive materials, including fission products and the transuranic elements.

Fuel decladding and/or dissolution methods have been developed for the most widely used power fuels, tubular stainless steel or Zircaloy-clad oxides, as well as for the less important uranium-zirconium alloys clad in Zircaloy-2, UO_2--stainless steel cermets clad in stainless steel, and alloys of uranium and molybdenum.

Feed preparation for stainless steel clad--oxide core fuels can be accomplished by (1) shear-leach; (2) sulfex decladding; (3) electrolytic dissolution; and (4) dissolution in aqua regia. For Zircaloy-2 clad--oxide core fuels, shear-leach and the Zirflex are applicable. A mixture of nitric and hydrofluoric acids will dissolve both cladding and core.

The cermets of oxides and stainless steel require aqua regia (in titanium equipment) or electrolytic dissolution in nitric acid. Hydrofluoric acid or ammonium fluoride solutions containing HNO_3 or H_2O_2 will dissolve zirconium-uranium alloys.

Processing methods for carbide fuels include: hydrolysis, acid dissolution,

and burning, and for graphite-based fuels: burning, grind-leach, and disintegration. Plutonium/uranium oxides can be dissolved in nitric acid/hydrofluoric acid; and beryllium oxide-based fuels can be dissolved in hydrofluoric acid, sulfuric acid, or ammonium fluoride.

The solvent extraction systems (Purex of Thorex) can be modified to recover thorium, uranium, protactinium, and plutonium from the feeds prepared by the above methods. Tri-butyl-phosphate (TBP) is the most used organic solvent, although others may be equally good. Laboratory-scale tests with prototype power fuels irradiated to 50 000 Mwd/tonne indicate satisfactory solvent stability with TBP. New diluents and new solvent cleanup cycles have been developed.

Solvent extraction and ion exchange processes have been developed for neptunium recovery. Plutonium-242 and an americium-curium-rare-earth fraction have been recovered from completely "burned" plutonium-239 by TBP extraction and ion exchange. Processes for the recovery of the transuranium elements are being developed using tertiary amines, phosphonates, TBP, and alkyl phosphoric acids. Solvent extraction and ion exchange processes for the recovery and separation of all valuable fission products are being developed and tested. Basic research is providing a better understanding of chemistry, mechanisms, and applications. High capacity centrifugal contactors have been tested for plant scale use; other high throughput, low holdup contactors are being developed.

The important cost components of fuel recycle, of which reprocessing is a significant but not controlling part, have been estimated. These costs are discussed as a function of plant capacity.